AGGRESSIVE SURGICAL MANAGEMENT OF STERNOCLAVICULAR JOINT INFECTIONS

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Background: **Although the sternoclavicular joint is an unusual site for infection, thoracic surgeons may preferentially be called on to coordinate management of cases refractory to antibiotic therapy because of the anatomic relationship of this joint to major vascular structures.** ***Methods:*** **Since 1994 we have surgically managed nine sternoclavicular joint infections in eight patients. Associated medical problems were frequent and included diabetes mellitus (n = 2), end-stage renal disease (n = 2), hematologic disorders (n = 2), and multiple joints affected by sepsis (n = 4). Open joint exploration with drainage and débridement with the use of general anesthesia was performed in four patients. The remaining four patients (one with bilateral sternoclavicular joint infections) had computed tomographic evidence of diffuse joint and surrounding bone destruction with infection extending into mediastinal soft tissues. Surgical therapy for these five joint infections involved en bloc resection of the sternoclavicular joint with an ipsilateral pectoralis major muscle covering the bony defect.** ***Results:*** **There were two deaths unrelated to the surgical procedure. After a mean follow-up of 20 months, the remaining six survivors (seven joints) have complete healing with no apparent limitation in the range of motion even after en bloc resection.** ***Conclusions:*** **Most cases of early sternoclavicular joint infections will respond to conservative measures. However, when radiographic evidence of infection beyond the sternoclavicular joint is present, en bloc resection, although seemingly aggressive, results in immediate eradication of all infection with negligible functional morbidity. Prolonged antibiotic therapy or continued local drainage procedures appear to have little value in these cases, adding only to patient care costs and the potential sequelae of chronic infections. (J Thorac Cardiovasc Surg 1997;113:242-7)**

The sternoclavicular joint (SCJ) is a synovial fluid–lined space consisting of the inferior portion of the medial head of the clavicle, a notch on the upper outer portion of the manubrium, and the cartilage of the first rib.[1] The articular capsule surrounding the joint is reinforced by the anterior, posterior, and interclavicular ligaments.[2] Infection of the SCJ is relatively uncommon. However, when infection does occur, the joint capsule and surrounding ligaments initially confine such processes. For most cases of early SCJ infection, removal of any indwelling subclavian venous catheter that may be a potential source of infection, intravenous antibiotics, and percutaneous joint aspiration, when appropriate, are effective.

Patients with SCJ infections frequently have associated risk factors, however, which may minimize symptoms or otherwise delay the patient's request for therapy, such as intravenous drug abuse or compromised host immunity.[3, 4] Development of osteomyelitis of the surrounding bony structures can be difficult to eradicate and even life-threatening, particularly in immunocompromised patients. Further delay in appropriate therapy may result in rupture of the joint capsule with infection tracking into the chest wall, retrosternum, or superior medi-

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Table I. *Patient data*

Patient	*Age, sex*	*Symptoms*	*Comorbidity; risk factors*	*Suspected source*	*Duration of antibiotics before referral (days)*
1	41, M	p,s,f	CML, BMT	SCV catheter	6
2	69, F	p,e,f	CAD, knee sepsis	SCV catheter	37
3	60, M	p,f	ESRD, DM, PVD, CAD, HTN	SCV catheter	11
4	40, M	p,f,d	Sickle cell disease, ESRD, multiple joint sepsis, endocarditis	SCV catheter	6
5	36, M	p,e,s	Heart block, SCV thrombus	SCV pacemaker	17
6	58, M	p,e,s	Tibia osteomyelitis, wrist sepsis	Bacteremia	27
7	40, M	p,e,s,d	Soft tissue trauma of arm	Lymphatic or vascular "seeding"	62
8	64, M	p,s	DM, HTN, Vertebral body osteomyelitis	Bacteremia	23

p, Pain; *s,* swelling; *f,* fever; *e,* erythema; *d,* discharge; *CML,* chronic myelogenous leukemia; *BMT,* bone marrow transplant; *CAD,* coronary artery disease; *ESRD,* end-stage renal disease; *DM,* diabetes mellitus; *PVD,* peripheral vascular disease; *HTN,* hypertension; *SCV,* subclavian vein.

astinum.[5] We describe an aggressive but rational approach used for the surgical management of nine SCJ infections refractory to conservative therapy at our institution based on clinical, radiographic, and operative findings.

Patients and methods

Patients. From May 1994 to March 1996, eight patients with nine SCJ infections were referred to the Indiana University Thoracic Surgery Service. Medical history, culture results, and suspected causes of each infection were collated from review of hospital charts. Radiographic data were obtained from review of routine radiographs, bone scans, and computed tomographic (CT) scans when available. This study comprised seven men and one woman with a mean age of 51.0 years (range 40 to 69 years). Their clinical characteristics are summarized in Table I.

Conservative measures, including at least one course of intravenous antibiotics, had failed in all patients. All patients had pain over the SCJ, which helped to establish the diagnosis. Swelling and cutaneous erythema were, however, not uniformly present. One patient underwent three incision and drainage procedures under local anesthesia, resulting in a mediastinal-cutaneous sinus tract, before being referred to the Thoracic Surgery Service. These patients were treated with antibiotics for an average of 23.7 days (range 6 to 62 days) and had a mean white blood cell count of 13.1×10^3 (range 5.8 to 27.1×10^3) at the time of referral. Except for one otherwise healthy patient, the patients in this series had significant comorbidity including diabetes mellitus ($n = 2$), end-stage renal failure ($n = 2$), hematologic disease ($n = 2$, leukemia and sickle cell disease), and multiple joints affected by sepsis ($n = 4$).

Five SCJ infections were attributed to an indwelling central venous catheter (one pacemaker) placed percutaneously in the subclavian vein (four ipsilateral, one contralateral). These central lines were indwelling for a mean of 39.6 days (range 7 to 90 days) before diagnosis. Two patients had other joints affected by sepsis (left knee and left wrist; thoracic spine), and another patient had a history of penetrating soft tissue injury to the ipsilateral forearm 14 days before the onset of symptoms. These three infections were attributed to hematogenous seeding of the SCJ.

Plain radiographs to evaluate the SCJ in this series were not uniformly helpful in establishing the diagnosis, nor did they demonstrate the extent of these infections. Bone scans, however, identified and localized the infection to the SCJ in seven joints (Table II). Not only were all CT scans diagnostic for SCJ infection but, more important, they defined the extent of bone and mediastinal involvement (Figs. 1 and 2). Skin pathogens were predominantly recovered, with *Staphylococcus aureus* being the most common bacterium, isolated from five joints. *Staphylococcus epidermidis, Enterococcus, Escherichia coli, Pseudomonas aeruginosa,* and *Propionibacterium* were also cultured either independently or in conjunction with *Staphylococcus aureus.*

Surgical therapy. Two operative techniques were used in this series as determined by CT findings or clinical severity when a CT scan had not been obtained. When the CT scan revealed periarticular inflammation without bony involvement or bony involvement limited to the clavicular head, open joint exploration with drainage and débridement was performed (four joints) with the patient under general anesthesia. A 3 to 4 cm oblique incision was made directly over the distal clavicle extending to the midline. The anterior aspect of the joint capsule was opened, and the joint was drained. Any infected soft tissue or bone was débrided. The clavicular head was removed in two patients after open exploration confirmed CT findings of osteomyelitis in one patient and for visual evidence of bone infection in another without a preoperative CT scan. After irrigation, the wound was managed by delayed primary closure ($n = 1$) or, in the last three patients, closure over standard surgical drains connected to an external suction system.

When CT demonstrated direct mediastinal extension with abscess formation or evidence of extensive adjacent bone involvement, en bloc resection of the joint including the surrounding bony structures and infected soft tissue was performed (five joints, one bilateral). A hockey-stick type of incision was made over the clavicle and sternal

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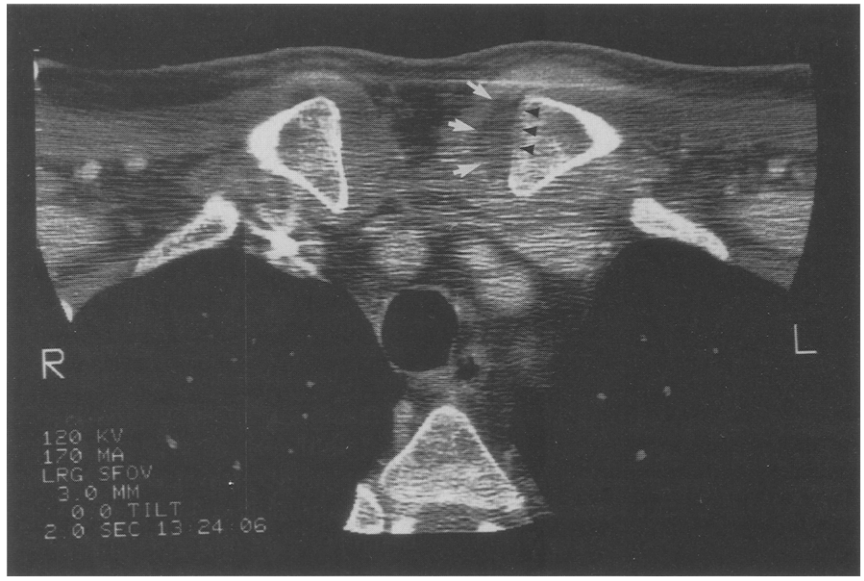

Fig. 1. Axial CT at the level of the clavicular heads. There is abnormal fluid density along the medial aspect of the clavicular head *(arrows)*. Note the absence of cortical bone of the left clavicular head adjacent to the fluid collection, consistent with osteomyelitis *(arrowheads)*. This patient underwent resection of the clavicular head.

Table II. *Diagnostic studies and treatment*

Patient	*Bone scan*	*CT scan*	*Cultures**	*Positive blood culture*	*Surgical procedure*
1	Positive	Inflammatory changes of SCJ	*Enterococcus, Staph. aureus*	Yes	JE & D
2	Positive	Spread into anterior mediastinum	*Pseudomonas aeruginosa*	Yes	SCJ resection
3	Positive	Bilateral SCJ infection, air-fluid levels	*Staph. aureus*	Yes	Bilateral SCJ resection
4	ND	ND	*Staph. aureus*	Yes	JE & D
5	ND	ND	*Propionibacterium, Staph. aureus*	No	JE & D, clavicular head resection
6	Positive	Osteomyelitis of medial clavicle	—	No	JE & D, clavicular head resection
7	Positive	Sinus tract into mediastinum	*Staph. aureus Staph. epidermidis*	Yes	SCJ resection
8	Positive	Osteomyelitis of clavicle and manubrium	*E. coli*	Yes	SCJ resection

JE & D, Joint exploration and drainage; *SCJ,* sternoclavicular joint; *ND,* not done.
*Obtained from needle aspiration, open drainage, or surgical specimen after resection.

midline from the midclavicular level to the approximate level of the fifth intercostal space. Any severely infected skin overlying the SCJ or mediastinal-cutaneous fistula was included with the specimen. The medial third of the clavicle, cartilaginous portion of the first rib, and lateral half of the manubrium were resected en bloc (Fig. 3, *A* and *B*). The horizontal and transverse manubrial osteotomies were made with a standard sternal saw; however, a Gille saw passed underneath the clavicle was used to divide this bone, thereby avoiding injury to the underlying subclavian vein. In four joints, the cartilaginous portions of the second and third ribs were involved and therefore resected with the remainder of the specimen, which required inferior extension of the manubrial osteotomy. One patient in this series underwent en bloc bilateral SCJ resection including the entire manubrium for bilateral infections. In all of these patients, the internal thoracic vessels were ligated at the superior and inferior margins of the chest wall resection and could not be spared because of periosteal inflammation. Careful attention was given during these resections to the underlying vascular structures, particularly the subclavian vein, which was found to be densely adherent to the posterior aspect of these infected SCJs. Despite careful dissection techniques, a

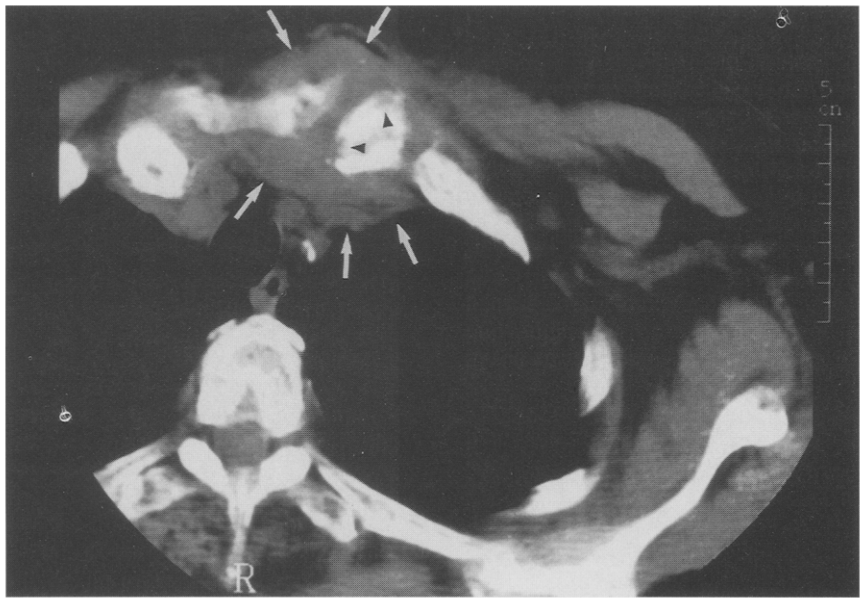

Fig. 2. Axial CT at the level of the clavicular heads. There is abnormal soft tissue density surrounding the left clavicular head and extending posteriorly, abutting the anterior part of the mediastinum *(arrows).* Note the areas of cortical disruption *(arrowheads),* consistent with osteomyelitis. This patient underwent SCJ resection.

tear occurred on one subclavian vein while the bony thoracic inlet was being removed, resulting in the acute loss of 400 ml of blood until control and repair could be effected. All chest wall defects were covered by mobilization and rotation of the ipsilateral pectoralis major muscle, preserving the thoracoacromial vascular pedicle, in conjunction with our Plastic Surgery Division. Suction drainage catheters were placed beneath the muscle and left until negligible drainage (<5 ml in 24 hours) occurred.

Postoperative care. All patients were immediately extubated after the procedure. Patients who underwent resection of the SJC were observed in the intensive care unit on the evening of the operation and then were transferred to the general ward on the first postoperative day. Ambulation was begun on the first postoperative day. Physical therapy, including active and passive range of motion exercises, was judiciously initiated on the second day and continued on discharge. After discharge, lifting was restricted to 5 pounds for the first month and then increased by 5 pounds per month for the next 3 months. Unrestricted lifting was allowed thereafter. Intravenous antibiotics were continued for approximately 10 days after en bloc resection inasmuch as all areas of osteomyelitis were removed and for 4 to 6 weeks after open drainage. Patients were allowed to complete intravenous antibiotic therapy at home when they otherwise met standard discharge criteria. One patient was discharged with drains in place, which were ultimately removed on an outpatient basis.

Results

After a mean follow-up of 20 months, the surviving patients have had no limitation in strength or range of motion of the ipsilateral limb even after SCJ resection. There have been no recurrent or persistent infections. The patient who underwent bilateral SCJ resection had a wound seroma that resolved with local drainage. There were two deaths in this series. One patient in the open drainage group died of refractory endocarditis 1 month after the operation. The other patient had undergone SCJ resection and died of a complication of a gastrointestinal hemorrhage 2 weeks after being discharged from the hospital. Both deaths were unrelated to the SCJ procedures. There has otherwise been no morbidity or mortality. Patients who underwent open drainage with débridement had an average hospital stay of 23.5 days (range 4 to 49) after the surgical procedure, whereas those who had SCJ resection stayed an average of 12.9 days (range 6 to 27).

Discussion

Infection of the SCJ mainly occurs in patients with predisposing conditions such as intravenous drug abuse, systemic diseases treated with steroids, diabetes, or chronic renal failure.[1] SCJ infections may occur as a result of hematogenous bacteremia but more commonly are a sequela of subclavian venous catheters in susceptible patients. Direct inoculation of the joint during attempts at percutaneous subclavian vein catheterization can occur. However, others

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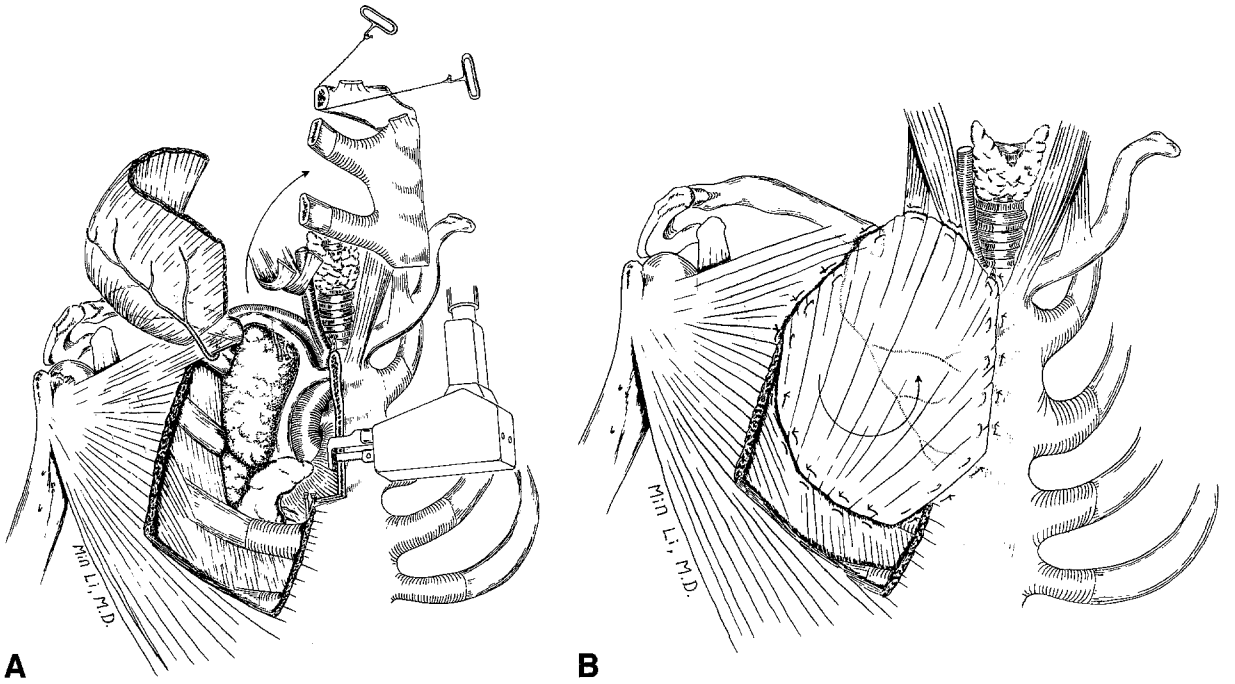

Fig. 3. A and B, En bloc SCJ excision including the first and second costal cartilages with pectoralis muscle coverage of the bony defect. (See text for details.)

have suggested that colonization of the catheter tract results in seeding of the SCJ capsule, which may have been traumatized at the time of insertion.[3] Our findings of *Staphylococcus aureus* as the most frequently isolated bacterium in catheter-related SCJ infections supports theories of more direct joint contamination by skin pathogens in these cases.[3, 4, 6-9]

Because of the increasing use of subclavian venous catheters, it is important to recognize SCJ infection as a rare but potential complication. At the first sign of symptoms, which is usually pain, the central venous catheter should be removed and anti-staphylococcal antibiotics administered through a peripheral vein. If the clinical diagnosis of SCJ infection is in question, bone scans have been highly sensitive in our series and others for detection of osteomyelitis.[10] When swelling and erythema are present, needle aspiration of the joint for both bacteriologic diagnosis and therapeutic drainage should be attempted. The majority of early SCJ infections in our experience have responded to these conservative measures. If infectious signs and symptoms do not rapidly resolve, CT scan with fine cuts through the SCJ should be obtained to determine the extent of infection before surgical intervention. Despite all current imaging modalities, however, we believe early open exploration with the patient under general anesthesia remains optimal from both diagnostic and therapeutic standpoints.

The time interval between SCJ infection and symptoms vary, and therefore a delay in diagnosis is not uncommon.[11] Moreover, repeated drainage procedures done with local anesthesia may result in inadequate initial therapy, especially in patients with compromised host immunity. In the later stages of SCJ infection, abscess formation with direct extension into the mediastinum and adjacent chest wall is reported to occur in as many as 21% of cases.[1, 12] Other CT findings in later stages include periosteal reaction, bony sequestra, reactive sclerosis, sinus tracts, and air-fluid levels.[10, 12, 13] In these advanced cases, en bloc resection of all infected tissue including the SCJ immediately resolves a situation in which prolonged antibiotic therapy has a low likelihood of success.

The SCJ is the only connection of the shoulder complex to the axial skeleton.[2] Motion at the SCJ contributes to shoulder abduction and flexion by elevation and rotation of the clavicle, respectively.[1, 2, 14] Although the SCJ contributes to the stability of the shoulder joint complex, removal results in minimal restriction of motion.[15] Seven cases of SCJ

resection for extensive infection have previously been reported, only one of which involved muscle coverage of the defect.[5, 12, 15, 16] These previous reports have originated from the orthopedic surgical literature. However, we believe that thoracic surgical expertise results in optimal care, particularly if resection is performed, because separation of the bony thoracic inlet from underlying vascular structures may be hazardous if the subclavian vein is adherent as a result of periosteal inflammation. In these previous reports, most surgical defects were left open and allowed to heal by secondary intention; although ultimately successful, this approach added to recovery time and patient care. We further believe that coverage of the exposed brachiocephalic vessels with vascularized muscle is important, not only to bring capillary ingrowth into a critical area probably containing low-grade infection but also for long-term protection of these vessels against external trauma. This principle has been previously well demonstrated by Pairolero, Arnold, and Harris[17] after sternal débridement for both local infection control and protection of the mediastinal structures after cardiac procedures.

The early diagnosis of SCJ infection is critical for successful therapy; however, thoracic surgeons are likely to encounter more advanced cases of these rare infections as the use of subclavian venous catheters and the number of immunocompromised patients continue to increase. An aggressive surgical approach including early open drainage and débridement done with general anesthesia or SCJ resection with muscle flap coverage for more advanced cases, although seemingly radical, appears to avoid prolonged hospitalization and sequelae of chronic infection.

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